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Impact of pharmacist-led educational and error notification interventions on prescribing errors in a family medicine clinic

Marquita B. Winder, Jeremy L. Johnson, Lourdes G. Planas, Kimberly M. Crosby, Brooke L. Gildon, and Linda A. Oberst-Walsh

Abstract

Objectives: To determine the rate of prescribing errors in a family medicine clinic and the subsequent impact of pharmacist-led educational and error notification interventions on prescribing errors.

Design: Single site, pre–post study design.

Setting: An outpatient academic family medicine clinic serving pediatric and adult populations in Oklahoma from March 1, 2011, through April 30, 2012.

Participants: 24 resident physicians who prescribed medications during routine outpatient visits.

Intervention: A prescribing educational program, audit and feedback methods, and weekly newsletter.

Main outcomes measure: Percentage of prescription errors and physician error rate before and after intervention among pediatric and adult populations.

Results: During the two assessment periods, 24 resident physicians wrote 2,753 prescriptions for 394 pediatric and 899 adult patients. The overall percentage of prescription errors decreased from 18.6% during March 2011 to 14.5% during April 2012 ($P = 0.004$). Errors were more commonly seen with prescriptions written for pediatric patients (24.9%) than for adult patients (13.9%) ($P = 0.001$). Individual physician error rates ranged from 5% to 36% (mean ± SD 16.5% ± 8.1). Physicians committed significantly fewer prescribing errors during the postintervention assessment period (14.9%) than during the preintervention assessment period (20.9%) ($P = 0.002$). Controlling for time, pediatric prescription error rates among physicians who participated in the educational intervention were 36% lower than the error rates among physicians who did not participate (rate ratio 0.64 [95% CI 0.45, 0.91], $P = 0.01$).

Conclusion: The pharmacist-led educational program was effective in reducing pediatric prescribing errors among resident physicians in a family medicine clinic.

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Marquita B. Winder, PharmD, Assistant Professor, School of Pharmacy, South University, and Clinical Pharmacy Specialist, Endocrinology, William Jennings Dorn Veterans Affairs Medical Center, Columbia, SC; at time of project completion, Postgraduate Year 2 Ambulatory Care Pharmacy Resident and Clinical Instructor, College of Pharmacy, University of Oklahoma, Tulsa, OK

Jeremy L. Johnson, PharmD, Assistant Professor, College of Pharmacy, Southwestern Oklahoma State University, Tulsa, OK; at time of project completion, Assistant Professor, College of Pharmacy, University of Oklahoma, and Adjunct Assistant Professor, Department of Family Medicine, School of Community Medicine, University of Oklahoma, Tulsa, OK

Lourdes G. Planas, BSPharm, PhD, Assistant Professor, College of Pharmacy, University of Oklahoma, Oklahoma City, OK

Kimberly M. Crosby, PharmD, Associate Professor, College of Pharmacy, University of Oklahoma, and Adjunct Associate Professor, Department of Family Medicine, School of Community Medicine, University of Oklahoma, Tulsa, OK

Brooke L. Gildon, PharmD, Assistant Professor, College of Pharmacy, University of Oklahoma, and Assistant Professor, Department of Pediatrics, School of Community Medicine, University of Oklahoma, Tulsa, OK

Linda A. Oberst-Walsh, MD, Residency Program Director, Department of Family Medicine, School of Community Medicine, University of Oklahoma, Tulsa, OK

Correspondence: Marquita B. Winder, PharmD, Assistant Professor, School of Pharmacy, South University, 10 Science Court, Columbia, SC 29203; mwinder@southuniversity.edu

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The deficiency in teaching of therapeutics and prescription writing principles in the medical school curricula is a current source of concern to medical educators and students.[1] This deficiency potentially contributes to a problem, as studies have shown that up to 21% of prescriptions contain at least one prescribing error.[2] Prescribing errors by physicians may challenge their efforts to make evidence-based medical decisions that promote patient safety.[3–7] For example, a prescription written for amoxicillin intended to be written 80–90 mg/kg/day but calculated at 150 mg/kg/day equates to an overdose, diminishing patient safety. Resulting errors may also contribute to increasing pharmacists' workload in various settings (e.g., community, inpatient, and outpatient) in an attempt to correct the aforementioned errors.[3,8–10] Furthermore, this may decrease the productivity of physicians or auxiliary personnel working call centers at outpatient clinics as they field and document calls from pharmacists to obtain additional information or confirm providers' intentions.[3]

Family practice residency programs have reported major errors of omission and commission.[11] Several studies have discussed the need for evaluation of prescribing errors in residency programs, as well as the development of educational interventions to improve prescribing skills among medical residents.[11,12] Recognizing rates and types of errors that occur before the development of educational programs has been advantageous in reducing prescribing errors.[12]

Several educational interventions to decrease prescribing errors have been studied. In a systematic review, the two most consistent prescribing interventions that showed a positive effect were "educational outreach visits" and "audit and feedback".[13] An educational outreach visit is defined as a method in which a knowledgeable health professional meets with prescribers to discuss prescribing issues. Audit and feedback is defined as any summary of clinical performance of health care over a specified time period provided to the health professional for consideration and input.[13] However, this review failed to determine the effects of pharmacist-led educational interventions, as few studies exist on this issue.

In a previous study conducted during a 6-month period, pharmacist-led interventions for internal medicine residents included a 1-hour lecture followed by biweekly, then monthly, discussions using institution-specific examples of prescribing errors. The intervention yielded a reduction in prescribing errors during active intervention, but effectiveness was not sustained postintervention.[14] In another study, a pharmacist-led educational program, combining a monthly quiz and informal discussion, for pediatric residents was implemented for 11 months. After quiz programming, there was a 90% decrease in potentially severe, fatal, or serious errors but without change in potentially significant or problematic errors.[15]

Reducing prescribing errors poses a challenge in various settings, and little is known about the effects of educational interventions on medical residents in outpatient settings. Furthermore, prescribing errors can be institution specific and should be identified before development of educational interventions to determine the most optimal approach.

Key Points

Background:

- Although many studies identify prescribing interventions and their effectiveness, few studies examine multiple interventions intended to improve medical residents' performances or to minimize prescribing errors in outpatient settings.
- Commonly occurring errors should be elucidated to determine optimal education approaches with regard to writing prescriptions.

Findings:

- This study expounded upon effective methods to improve prescribing and influence resident physician behavior.
- Incorporation of a pharmacist-led intervention into resident physicians' training curricula has proven beneficial to reducing prescribing errors for pediatric patients.

Objectives

The objectives of this study were to identify rates of prescribing errors, implement educational and error notification interventions based upon the most common types of errors identified, and evaluate the impact of the educational and error notifications interventions on medical residents' prescribing errors.

Methods

The study used a single-site, pre–post study design. The study was approved by the academic medical center's institutional review board. The study comprised four phases: preintervention error assessment (March 2011); educational intervention; error notification interventions, which included audit and feedback and weekly newsletters; and postintervention error assessment (April 2012). When selecting months of data collection, consideration was given to months during which new residents enter the family medicine program (July) as well as months of increased prescribing (cold and influenza season).

During summer 2011, a report of prescriptions issued in March 2011 by family medicine resident physicians was generated and served as the preintervention data source. Prescriptions were assessed to identify the number and types of prescribing errors (defined as transcription errors, failure to communicate essential information, and the use of drugs or doses inappropriate for the individual patient).[16,17]

This was a continuous quality improvement study in which the medical residency director was fully involved and aware. All residents were informed and had full knowledge of the program. Resident involvement was voluntary; however, no one declined to participate. No penalty was issued as a result of erroneous prescription writing. Similar studies (Condren and colleagues, Honey and colleagues, and Neuspiel and colleagues) used the same nonpunitive interprofessional approach in identifying and reporting medication errors.[12,18,19]

Resident physicians gain practice experience with all ages in continuity clinics, including pediatric patients. Patients at the practice site are generally of a lower socioeconomic status and many have state Medicaid coverage. Resident physicians spend one-half day per week in the ambulatory clinic setting during the first year of residency and 3 to 4 half-days per week during the second and third years of residency; they complete 1,700 to 2,300 office visits each by the end of their residencies. The clinic is a multidisciplinary, patient-centered medical home team incorporating family and sports medicine physicians, clinical pharmacists, psychologists with expertise in family systems and research, nurses, physician assistants, social workers, licensed nurse practitioners, radiology technicians, and patient service representatives. Averaging 2,700 visits per month, the clinic serves 92,000 active patients, of whom approximately 43% are younger than 19 years, 36% are 19 to 49 years of age, and 21% are 50 years or older.

Study interventions

The first study intervention, an educational outreach visit, was an optional prescribing educational program offered to medical residents during one of their scheduled residency learning opportunities. The 1-hour program on writing prescriptions was designed and executed by the principal investigator.

The program focused on prescribing errors, especially those most commonly identified preintervention. The program also detailed applicable use of tools available in the electronic medical record (EMR), drug information resources available within the EMR, and necessary elements for writing a prescription (e.g., legal requirements, what a community pharmacist is allowed to change legally without the provider's consent).

Topics presented included: using custom medication lists, dosing calculator in the EMR, drug information resources, writing prescriptions, unavailable medications, unapproved abbreviations, new medication labeling, and the prescription review process. As incomplete prescription/inadequate prescription was the error most commonly found in the preassessment phase, it was determined that resident physicians were not using the custom medication list with prepopulated fields.

The educational program was delivered in an active learning format and included questions using an audience response system as well as practice calculations for pediatric prescriptions (see the online Appendix for interview questions, available on JAPhA.org in the Supplemental Content section). Content validity of lecture material and approach of delivery were established by faculty of the college of pharmacy whose primary clinic site was the study setting, and also by pharmacists who participated in outpatient error prevention training at other facilities within the study site's academic institution.

For the second intervention involved we implemented an audit and feedback method and a weekly newsletter. Prescriptions written by all residents were reviewed daily to identify errors, after which notifications of errors were sent to the corresponding prescribers via EMR alerts/flags that functioned as an internal messaging system. EMR alerts/flags for errors with more likelihood to cause harm detailed when the review was completed, what error was found, recommendations for how to correct the error, and an offer of assistance from clinical pharmacists. Errors found were reported to the institution's risk management department.

Verbal feedback was provided as needed to prescribers based upon the level of severity of the error. The primary investigator used professional judgment agreed upon by coinvestigators as evidenced by the initial 50 reviews conducted to ensure agreement on the assessment and severity of error. Additionally, over a 3-month period following the educational outreach, all residents were sent a weekly newsletter of common errors via the family medicine email list. Weekly newsletters included contact information for clinical pharmacists, common errors identified during the previous week, error type, example of the error, recommendations for correction, and highlights from the educational outreach. A postintervention error assessment of prescriptions issued by family medicine residents during April 2012 was conducted. This period lasted for 3 months after the educational outreach intervention, which was approximately 1 year after the preintervention error assessment. The pre- and postintervention assessments were conducted 1 year apart so that similar types of prescriptions could be assessed based on seasonal illnesses and prescribing habits.

Prescription assessment and prescribing errors

Prescriptions were reviewed and prescribing errors classified by the principal investigator based on common prescribing errors identified in other studies,[2,12] such as directions unclear, dose missing, frequency missing, frequency outside recommendation, inappropriate dose for age, and wrong drug selected from list.

Prescriptions with "take as directed" were considered in the "directions unclear" category unless the indication was specified or the medication had a single labeled indication approved by the Food and Drug Administration. Unclear quantity on topical prescriptions was also considered an error because, with limited information, a pharmacist may dispense an inadequate amount for a specific area for application or duration of therapy. Prescriptions written at least 10% outside normal dosing ranges were classified as "dose above recommendation" or "dose below recommendation".[12,20]

All prescriptions were generated using the EMR, and thus all prescriptions were included. Prescriptions were printed and given to the patient, e-prescribed, or telephoned to the patient's pharmacy of choice.

Each prescription was assessed for date, patient's age, patient's weight, physician's name, the name of the drug prescribed, classification of drug (e.g., antibiotic, analgesic), dose, formulation/route, dosing frequency, quantity, concurrent number of prescriptions written for patient, and instructions for use. Other variables collected included patient age [pediatric (0 months to 18 years) vs. adult (over 18 years)] and resident physician postgraduate year (PGY) of training (PGY1, PGY2, PGY3, or PGY4).

A stable group of family medicine residents rotated in ambulatory clinics during the study period. No new residents entered the program during the study period. All residents were informed and had full knowledge of this quality improvement program. Residents who did not prescribe during both time periods were excluded from the analysis. Residents who graduated or were offsite during the study were also excluded. This study included prescriptions written for both prescription and nonprescription medications. Prescriptions for diabetic supplies or medical equipment were excluded.

An initial subset of approximately 50 prescriptions was reviewed independently by the principal investigator and two study investigators to identify prescribing errors. Agreement was found among all reviewers. From that point forward, all prescriptions were reviewed twice by the principal investigator.

Data analysis

Data were analyzed using SPSS version 20 (IBM) and SAS version 9.3 (SAS, Cary, NC). Descriptive statistics were calculated for the study variables. The outcome variables of interest were percentage of errors and prescriber error rates. These variables were also differentiated for pediatric prescriptions and adult prescriptions.

Two bivariate analyses using Pearson chi-square tests were conducted to test associations between prescription errors (yes or no) and time (preintervention or postintervention), and between prescription errors (yes or no) and patient population (pediatric or adult). The unit of analysis for these tests was the prescription.

A third bivariate analysis was conducted using the physician as the unit of analysis. Error rates for each of the 24 physicians were calculated. Using time as a within-subject grouping variable, a paired *t* test was conducted to compare the mean physician error rates before and after the interventions.

A generalized estimating equation (GEE) approach was used to determine the influence of time and physician participation in the educational intervention on the proportion of prescribing errors in the study sample, as well as among prescriptions for adult and pediatric patients. Interaction terms (time * education) were tested, but removed if not statistically significant. A GEE approach was used for these analyses to account for within cluster correlation (i.e., prescriptions written by individual physicians). A log link function, Poisson distribution, and unstructured correlation structure were used.

The a priori alpha level for all analyses was 0.05.

Results

A total of 52 prescribers wrote 3,989 prescriptions during the preintervention and/or postintervention periods. The 28 prescribers who did not write prescriptions during both time periods were excluded from analysis. The remaining 24 resident physicians wrote 2,753 prescriptions for 394 pediatric and 899 adult patients (Table 1).

On average, physicians wrote between three and four prescriptions per patient visit. The majority of physicians were in their first or second year of residency at the beginning of the study.

The prescription error type category with the highest incidence of errors was incomplete/inadequate prescription. For example, a prescription was written for cyclobenzaprine 10 mg tablets for an adult with no instructions. Another prescription was written for nystatin suspension with directions "2 mL qid. Use 48 × 48 hours after symptoms resolve" for a pediatric patient.

Table 1. Prescription, patient, and physician characteristics

Characteristics	Preintervention	Postintervention
Prescriptions (n = 2,753)		
Number	1,217	1,536
Mean	3.79 ± 2.85	3.38 ± 2.36
Patients (n = 1,293)		
Pediatric	166	228
Adult	393	506
Physicians (n = 24)		
PGY1	13	
PGY2	7	
PGY3	2	
PGY4	2	

Abbreviation used: PGY, postgraduate year.

Table 2. Prescribing errors before and after interventions

Prescription error type[a]	Preintervention[b]	Postintervention[c]
Incomplete/inadequate prescription	121	105
Directions unclear	35	53
Dose missing	12	7
Strength missing	5	2
Quantity calculated in error	9	6
Quantity missing	6	2
Frequency missing	11	4
Quantity sufficient with no days-supply	12	2
Instructions missing	6	2
Unclear quantity on topical	25	27
Dosing outside recommended	32	29
Duration outside recommendation	0	1
Frequency outside recommendation	14	9
Dose above recommendation	6	7
Dose below recommendation	12	12
Drug selection errors	41	51
Dosage form not available	3	0
Wrong dosage form	0	2
Sig/dosage form mismatch	17	28
Inappropriate for age	3	0
Wrong drug selected from list	17	21
Inappropriate for specified indication	1	0
Administration error	3	3
Technique not recommended	0	2
Immeasurable dose	3	1
Unapproved abbreviations	51	49

[a] From references 2 and 12

[b] 226 (18.6%) of 1,217 prescriptions contained 1 to 2 errors.

[c] 222 (14.5%) of 1,536 prescriptions contained 1 to 2 errors.

Types and incidence of prescribing errors are listed in Table 2.

During the preintervention assessment period, 226 of 1,217 (18.6%) prescriptions were identified with errors compared with 222 of 1,536 (14.5%) prescriptions during the postintervention assessment period. A statistically significant association was found between the rates of preintervention and postintervention prescribing errors ($\chi^2 = 8.47$; df = 1; $P = 0.004$). Overall, errors were more commonly seen among pediatric prescriptions (147 of 591; 24.9%) than among adult prescriptions (301 of 2,162; 13.9%) ($\chi^2 = 40.85$; df = 1; $P = 0.001$).

Among the 24 physicians, error rates ranged from 5% to 36%. The overall mean (± SD) error rate among physicians was 16.5 ± 8.1%. The mean postintervention physician error rate (14.9%) was significantly less than the mean preintervention physician error rate (20.9%) ($P = 0.002$).

Of the 24 resident physicians, 14 participated in the educational program. Physician error rates during the preintervention and postintervention assessment periods, stratified by participation in the educational program, are depicted in Table 3. Figure 1 depicts the proportions of adult and pediatric prescribing errors, stratified by physician participation in the educational program, during the preintervention and postintervention assessment periods.

An overall GEE analysis revealed that the rate of physicians committing a prescribing error was 23% lower during the postintervention assessment period than during the preintervention assessment period (rate ratio 0.77 [95% CI 0.66, 0.91], $P = 0.003$). Controlling for time, participating in the educational program did not significantly change the rate of committing a prescribing error.

The results of the GEE analysis for adult prescriptions were similar with a 23% lower rate of committing a prescribing error during the postintervention assessment period (rate ratio 0.77 [95% CI 0.62, 0.95], $P = 0.014$), yet no statistically significant difference for participating in the educational program was found (Table 4). Based on the GEE analysis for pediatric prescriptions, controlling for time, the rate of committing a prescribing error was 36% lower among physicians who participated in the educational intervention compared with those who did not (rate ratio 0.64 [95% CI 0.45, 0.91] $P = 0.01$). However, controlling for educational intervention participation, the rate of committing a prescribing error was not significantly different between the preassessment and postassessment periods (Table 4).

Discussion

In this study, resident physicians committed more prescription writing errors with regard to prescriptions for pediatric patients. Certain functionalities of the computer-based physician order entry may have increased the likelihood of committing a prescribing error, especially in the pediatric population. A statement endorsed by the American Academy of Pediatrics discusses the inadequacies of e-prescribing systems, such as lack of required features involving weight-based dosing calculations, dose-range checking, and indication-based dosing.[21]

Although these features were present within the EMR used in this study, optimal use may not have been

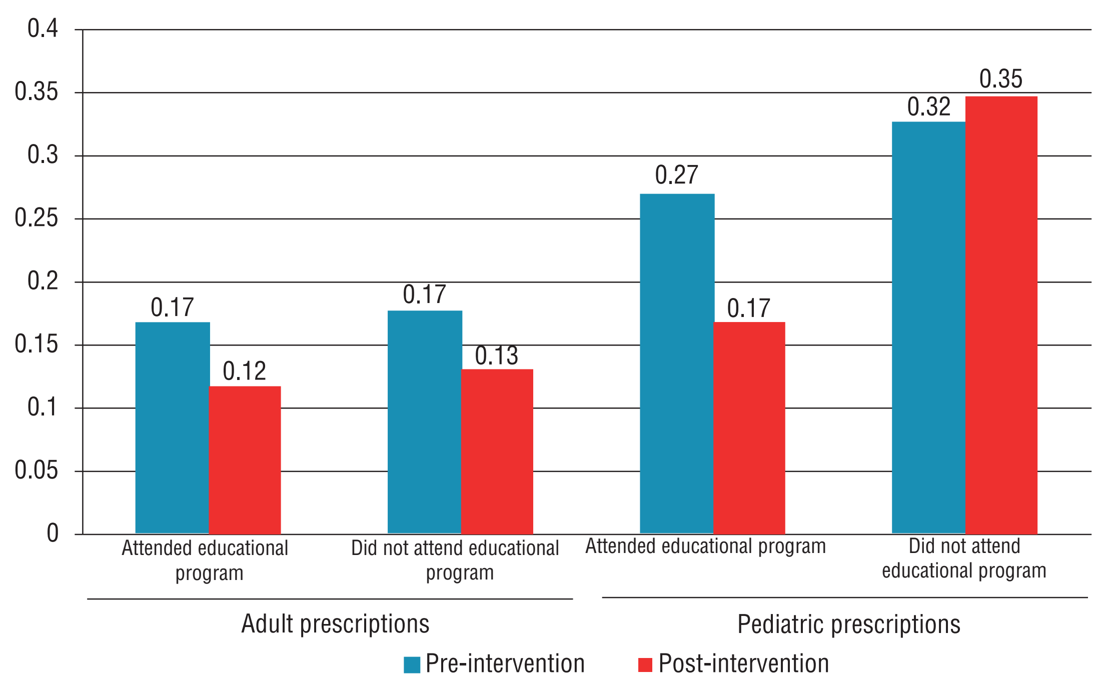

Figure 1. Proportion of adult and pediatric prescribing errors before and after interventions stratified by educational program attendance

employed before the pharmacist-led educational intervention, as evidenced by the prescriptions that were assessed. Examples of investigator-observed suboptimal EMR usage include improper use of the dosing calculator, not rounding measurements appropriately, and lack of knowledge of resources available within the EMR. Clinical decision support systems rely upon the user to input accurate information. Pediatric requirements for safe and effective prescribing include weight in kilograms, age, and height in centimeters.[21] This may suggest that EMR training specific to pediatric prescriptions needs to be incorporated in the formal training of the resident physicians at the study site. The focus on these issues during the educational intervention may have been why residents who attended the educational sessions showed significant improvement in prescribing for pediatric patients.

When stratified by study population, the study findings, specifically those of the adult GEE analysis, suggest that the error notification interventions (i.e., audit and feedback, newsletters) may have been effective in reducing errors among adult prescriptions. However, the extent to which these notification interventions influenced the physician error rate is confounded with time. Physicians may have improved simply by gaining an additional year of residency experience. Future research should further distinguish the effects of each type of error notification delivery method (i.e., audit and feedback, newsletter) on prescribing error rates.

Table 3. Prescription error rates among prescribers

Prescriber	Preintervention % Errors (± SD)	Postintervention % Errors (± SD)
Physician participated in educational program		
Yes (n = 14)	19.5 ± 8.7	12.4 ± 9.3
No (n = 10)	22.8 ± 10.5	18.5 ± 10.2
Overall mean ± SD (n = 24)[a]	20.9 ± 9.4	14.9 ± 1.0

[a] t test = 3.39, df = 23, P = 0.002

Table 4. GEE regression of proportion of prescription errors for adult and pediatric patients

	Adult patients				Pediatric patients			
Parameter	Estimate	SE	95% CI	Z (P)	Estimate	SE	95% CI	Z (P)
Intercept	–1.73	0.18	–2.09, –1.38	–9.56 (<0.001)	–1.04	0.10	–1.24, –0.84	–10.43 (<0.001)
Time	–0.26	0.11	–0.47, –0.05	–2.45 (0.014)[a]	–0.22	0.16	–0.53, 0.08	–1.44 (0.149)
Educational intervention	–0.15	0.22	–0.57, 0.27	–0.70 (0.487)	–0.44	0.18	–0.80, –0.09	–2.49 (0.013)[b]

Abbreviations used: GEE, generalized estimating equation; CI, confidence interval; SE, standard error.

[a] Rate ratio 0.77 [95% CI 0.62, 0.95]

[b] Rate ratio 0.64 [95% CI 0.45, 0.91]

Pharmacist-led interventions for various training programs have proven beneficial in reducing medication errors by using educational sessions,[14] participating in medical rounds,[22] administering assessments,[15] and providing medication surveillance.[18] A pilot of a prescription competency curriculum for family medicine residents also proved successful.[23] A previously conducted survey revealed that approximately 30% of family medicine residency programs in the United States have a clinical pharmacist working within their program.[24] Suggested guidelines exist for pharmacotherapy curricula in family medicine residency training to include prescription writing.[25]

Our study site employs two clinical pharmacists involved mostly in patient care and some teaching. Our study findings show that pharmacists' involvement in pharmacotherapy education and medication surveillance positively influence pediatric prescribing. Suggested training for those involved in pediatric prescription writing include instruction in medication error prevention at the earliest stage of training; instructions, practice, and assessments in performing mathematical calculations; and extensive education regarding the pediatric population.[26]

To our knowledge, before the interventions reported in this article, minimal education was being provided in the aforementioned areas. Optimally, additional funding will allow for further engagement to fulfill educational requirements and teaching within the family medicine residency training program.[25] Recognizing rates and types of errors occurring before the development of educational programs has been advantageous in reducing prescribing errors in a pediatric population.[12,20]

The results of this study suggest that a pharmacist should be involved in educational intervention implementation strategies as well as in design and improvement of EMR prescribing systems. In earlier studies, error rates in family medicine clinics ranged from 14% to 21%.[2,27,28] Shaughnessy and colleagues reported that on average, 21% of all prescriptions evaluated contained at least one error; of those, 39% were errors of omission defined as essential components not present. These omissions prevented pharmacists from executing the prescription.[2]

Another study reported common minor errors of omission such as physician stamp, date, and age.[11] Omission of age can result in unsafe practices as appropriate dose cannot not be determined for age. Common major errors of omission included dosage form and length of therapy.[11] Pediatric prescriptions and adult prescriptions were not treated separately in previous studies. Errors of omission accounted for the most common prescribing error in our study as well, corresponding to incomplete/inadequate prescription. Although patient harm from incomplete prescriptions may not be imminent as pharmacists are required to have all relevant information before dispensing a prescription, it does imply that pharmacy regulations and pediatric requirements should be covered during residency training.

Limitations

Several limitations of this research merit discussion.

The study findings may be unique to this setting and should not be generalized for all outpatient academic family medicine clinics. Prior exposure among physician residents to prescription writing education was unknown. We are also unaware of the impact of the Hawthorne effect on physicians and its possible contribution to improvement in error rates.

In this study, prescriptions were not presented to and dispensed by an in-house pharmacy. We were thus unable to determine whether community pharmacists intervened before dispensing medications.

The number of prescribers requiring verbal feedback was not tracked. All verbal feedback was documented in the EMR corresponding to the patient and the prescription.

Conclusion

Incorporation of pharmacist-led educational interventions into a resident physicians' training curriculum significantly reduced prescribing errors in the pediatric but not the adults population. Fundamentals of prescription writing and functionality of EMR clinical decision support systems should be explained before instructions on prescription writing are given to further decrease the likelihood of prescription errors.

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